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(71) Applicant (*for all designated States except US*): INTERCELL WIRELESS CORPORATION [US/US]; Suite 250, 7201 E. Camelback, Scottsdale, AZ 85251 (US).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): EL-SHARAWY, El-Badawy, Amien [EG/US]; 4134 East Spur Avenue, Gilbert, AZ 85296 (US).

(74) Agents: GRESHAM, Lowell, W. et al.; Suite 409, 5727 N. Seventh Street, Phoenix, AZ 85014 (US).

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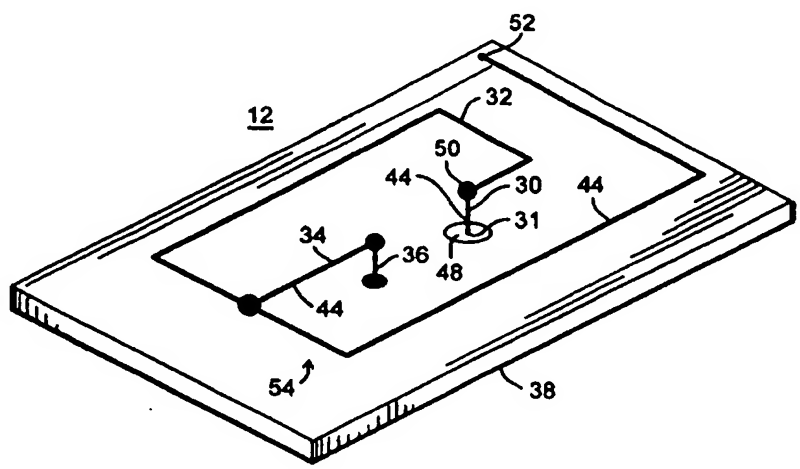

(57) Abstract

A portable telephone (10) has an antenna (12) which has attenuated near field transmitted RF signal emissions in the direction (28) of a user and substantially omnidirectional far field RF emissions. The antenna (12) includes a ground plane (38) positioned in the user direction (28) from antenna radiating elements (44). The radiating elements (44) are configured to cause the antenna (12) to resonate at a lower frequency (58) and a higher frequency (62). The radiating elements (44) are further configured so that the lower resonant frequency (58) is below the bandwidth (56) of the antenna (12) and so that the higher resonant frequency (62) is above the bandwidth (56) of the antenna (12).

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DUAL RESONANCE ANTENNA FOR PORTABLE TELEPHONE

Technical Field

The present invention relates generally to the field of antennas. More specifically, the present invention relates to antennas which are suitable for portable telephone use due to near field attenuation of transmitted signals in one direction and a relatively wide bandwidth.

Background Art

The use of portable telephones, and particularly portable cellular telephones which utilize L Band and/or S Band frequencies, poses health concerns for portable telephone users. In normal use, transmitted energy radiates from a portable telephone antenna located immediately adjacent to the user's head. Electromagnetic energy in the S and L Bands is absorbed by and otherwise influences organic matter, such as human brain and other tissues. Up to 50% or more of the energy radiated in the direction of a user's head can be absorbed by the user's head.

In order for the portable telephone to be able to communicate more than a few hundred feet, a portable telephone antenna radiates a substantial amount of L Band or S Band energy. A typical AMPS cellular portable telephone transmits at a power level of around 600 mw. Since many portable telephone users spend a significant amount of time using their portable telephones, the opportunity exists for serious cumulative health effects. Accordingly, a need exists for a portable telephone which protects the user from at least a portion of the electromagnetic energy transmitted from portable telephones. Workable portable telephones meet severe constraints. For example, one might devise a portable telephone which uses a remote antenna so that antenna emissions do not emanate from a location in close proximity to a user's head. However, this solution would so seriously diminish the convenience of the portable telephone that it would prove to be unworkable. Likewise, portable telephones comply with severe weight, size and cost constraints. Possible radiation emission solutions which might lead to increases in portable telephone cost or weight or require excessively large antennas would also prove to be unworkable. Many microstrip antennas have been adapted to various applications having L and S Band frequencies. Unfortunately, microstrip antennas tend

to be both too heavy and too costly for portable telephone use due to the dielectrics included therein.

Furthermore, portable telephones and their antennas comply with particular bandwidth and directionality constraints. For conventional AMPS cellular telephony, a portable telephone operates over a relatively wide bandwidth of approximately 824 MHz to 896 MHz, or approximately 8% of the center frequency. This relatively wide bandwidth causes a conventional technique of using shielding with a conventional antenna design to attenuate near field radiation in one direction to be unworkable. Conventional shielding techniques tend to either narrow bandwidth or fail to maintain the impedance necessary for satisfactory performance over the entire bandwidth. Moreover, portable telephones use generally omnidirectional antenna patterns so that communication service quality will not vary depending upon which direction a user faces at any given instant.

Disclosure of Invention

Accordingly, it is an advantage of the present invention that an improved dual resonance antenna for use with a portable telephone is provided.

Another advantage is that a lightweight antenna which is suitable for portable telephone use is provided.

Another advantage is that a low cost antenna which is suitable for portable telephone use is provided.

Another advantage is that a physically small antenna which is suitable for portable telephone use is provided.

Another advantage is that an antenna which is substantially omnidirectional in the far field but directional in the near field is provided.

Another advantage is that an antenna which has a relatively wide bandwidth is provided.

Another advantage is that an antenna which has an impedance of around 50 Ω throughout its subject bandwidth is provided so that the antenna may be directly driven by conventional transmission line drive circuits.

The above and other advantages of the present invention are carried out in one form by a dual resonance, wide bandwidth antenna having an antenna bandwidth positioned between resonances and attenuated near field response in one direction. The

antenna includes a conductive ground plane, a feed point, and an elongated conductor. The elongated conductor is spaced away from the ground plane and has a feed end and an open end. The feed end couples to the feed point. The antenna also includes a conductive shorting arm which has first and second ends. The conductive shorting arm first end couples to a central region of the elongated conductor. The conductive shorting arm is also spaced away from the ground plane. A shorting post couples between the second end of the conducting shorting arm and the ground plane.

Brief Description of Drawings

A more complete understanding of the present invention may be derived by referring to the detailed description and claims when considered in connection with the Figures, wherein like reference numbers refer to similar items throughout the Figures, and:

FIG. 1 shows a schematic cut-away side view of a portable telephone which incorporates a dual resonance antenna internal to a portable phone;

FIG. 2 shows a perspective view of a first embodiment of the antenna;

FIG. 3 shows a perspective view of a second embodiment of the antenna;

FIG. 4 shows a perspective view of the first embodiment of the antenna with various resonator lengths designated;

FIG. 5 shows an impedance curve which characterizes a first resonance of the antenna;

FIG. 6 shows an impedance curve which characterizes a second resonance of the antenna;

FIG. 7 shows an impedance curve which characterizes first and second resonances combined;

FIG. 8 shows a schematic cut-away side view of a portable telephone which incorporates an external embodiment of a dual resonance antenna;

FIG. 9 shows a perspective cross-sectional view of an external embodiment of the dual resonance antenna; and

FIG. 10 shows a cross-sectional view of a base of the external embodiment of the dual resonance antenna.

Best Modes for Carrying Out the Invention

FIG. 1 shows a schematic cut-away side view of a portable telephone 10 which incorporates a dual resonance antenna 12. Telephone 10 includes a housing 14 in which antenna 12 and other devices are enclosed. These other devices include a speaker 16, display 18, keypad 20, microphone 22, battery 24, and various electronic circuit cards 26. Of course, not all portable telephones 10 have components arranged precisely as illustrated in FIG. 1. Nevertheless, speaker 16 and microphone 22 define a user direction 28, indicated by an arrow in FIG. 1. User direction 28 points toward a user's head when telephone 10 is being used. Speaker 16 is placed in the vicinity of the user's ear, and microphone 22 is placed in the vicinity of the user's mouth.

The embodiment of antenna 12 depicted in FIG. 1 includes a conductive feed post 30, an elongated conductor 32, a conductive shorting arm 34 which may be viewed in FIG. 2, a conductive shorting post 36, and a conductive ground plane 38. Feed post 30, elongated conductor 32, shorting arm 34 (see FIG. 2), and shorting post 36 represent radiating elements of antenna 12. These radiating elements are positioned in a direction from ground plane 38 substantially opposite to user direction 28. Accordingly, ground plane 38 serves to shield the near field in user direction 28, where the user's head resides during normal use of telephone 10.

FIG. 1 illustrates one embodiment of the present invention in which ground plane 38 is clad onto the back of a substrate portion 40 of a circuit card 26. Electronic components 42 may be mounted on the front of substrate 40. Components 42 may provide, among other functions, the final stages of a transmitter for portable telephone 10. Desirably, inexpensive and conventional 50 (drive circuits and transmission lines are used. Accordingly, antenna 10 may be driven by signals which exhibit frequencies within the bandwidth of antenna 12 through ground plane 38 by coupling a feed point 31 of feed post 30 to components 42 using conventional 50 (transmission line techniques.

Moreover, forming ground plane 38 onto the back of substrate 40 causes ground plane 38 to add no significant weight to portable telephone 10. Consequently, the weight of antenna 12 is substantially defined by the weight of feed post 30, elongated conductor 32, shorting arm 34, and shorting post 36. These elements can weigh less than a conventional external monopole portable telephone antenna. Consequently, the use of antenna 12 causes portable telephone 10 to weigh less than its conventional counterpart while reducing near field emissions in user direction 28. While FIG. 1 depicts an embodiment of the present invention in which ground plane 38 is clad onto

substrate 40, this is not a requirement of the present invention. Nothing prevents antenna 12 from including a ground plane 38 which is not attached to substrate 40. Even when ground plane 38 is not attached to substrate 40, antenna 12 can still weigh less than a conventional external monopole portable telephone antenna.

While antenna 12 attenuates near field radio frequency (RF) emissions in user direction 28, far field emissions achieve a substantially omni directional pattern, roughly equivalent to the patterns achieved by conventional omni directional external monopole portable telephone antennas. Neither type of antenna achieves a precisely uniform omni directional far field pattern. A conventional omni directional external monopole portable telephone antenna has a pattern which is slightly attenuated in user direction 28 due to the absorption of significant amounts of RF energy by a user's head. Antenna 12 has a far field pattern which is slightly attenuated in user direction 28 due to the reflection of RF energy by ground plane 38 toward a direction substantially opposite to user direction 28. Because this energy is reflected rather than absorbed, antenna 12 exhibits improved performance compared to a conventional monopole antenna.

FIG. 2 shows a perspective view of a first embodiment of antenna 12. Feed post 30, elongated conductor 32, shorting arm 34, and shorting post 36 are collectively referred to as radiating elements 44. Radiating elements 44 are constructed from a relatively rigid conductive material which can support its own weight without deformation. In the preferred embodiments, radiating elements 44 are formed from solid, rigid wire. Accordingly, radiating elements 44 can mechanically support their own weight without requiring a separate substrate to physically support their set shape and position. The omission of one or more separate substrates to carry radiating elements 44 is not a requirement of the present invention. However, the omission of a separate substrate reduces the weight of antenna 12. In addition, the omission of substrates for carrying radiating elements 44 allows the dielectric constant of a volume of space 46 residing between elongated conductor 32 and ground plane 38 to remain low so that the gain and bandwidth of antenna 12 are not adversely affected.

Feed post 30 generally extends perpendicularly through ground plane 38 from feed point 31 for a distance of around 0.25 to 0.5 inches in an AMPS cellular application (i.e. bandwidth of 824 MHz to 896 MHz). An insulator 48 may isolate feed post 30 from ground plane 38 at the point where feed post 30 passes through ground plane 38. Feed post 30 spaces elongated conductor 32 and shorting arm 34 away from ground

plane 38 while simultaneously supporting radiating elements 44 in their desired position juxtaposed over ground plane 38.

Elongated conductor 32 extends from a feed end 50 to an open end 52. Desirably, elongated conductor 32 is shaped to reside substantially in a common plane in space which parallels but is spaced apart from ground plane 38. In this preferred embodiment, elongated conductor 32 is arranged in a spiral shape, one example of which is illustrated in FIG. 2, to conserve the amount of area consumed by antenna 12. FIG. 3 shows a perspective view of a second embodiment of antenna 12. In this second embodiment, elongated conductor 32 has a different spiral arrangement from that illustrated in FIG. 2. In other alternate embodiments, feed ends 50 can be located at outward ends of the spirals while open ends 52 can be located at interior ends of the spirals (not shown).

Referring to FIGs. 2 and 3, elongated conductor 32 is mutually configured in cooperation with ground plane 38 so that ground plane 38 covers a larger area than elongated conductor 32 and its projection onto ground plane 38. Ground plane 38 has a slightly larger site than elongated conductor 32 to effectively shield against near field RF emissions in user direction 28 (see FIG. 1). On the other hand, the site of ground plane 38 is desirably not much larger than the site of elongated conductor 32 so that antenna 12 will require as little space as possible.

Feed end 50 of elongated conductor 32 couples to feed post 30 at the end of feed post 30 distally located from feed point 31 (i.e., the point where feed post 30 passes through ground plane 38). Open end 52 of elongated conductor 32 is electrically open. However, open end 52 may have a dielectric cap thereon (not shown) or otherwise be supported by a small dielectric post (not shown) extending to ground plane 38 for mechanical support.

Shorting arm 34 couples to elongated conductor 32 at a point in a central region 54 of elongated conductor 32. Shorting arm 34 desirably extends away from elongated conductor 32 in a direction which will lead to no more than weak mutual coupling with elongated conductor 32, and shorting arm 34 desirably does not extend directly toward ground plane 38. In this first embodiment, shorting arm 34 extends perpendicularly away from elongated conductor 32 in the plane in space defined by elongated conductor 32 for a distance which is greater than the spacing between ground plane 38 and elongated conductor 32.

A first end of shorting post 36 couples to shorting arm 34 at the end of shorting arm 34 distally located from the point where shorting arm 34 couples to elongated conductor 32. A second end of shorting post 36 couples to ground plane 38. Shorting post 36 applies an electrical short to radiating elements 44 while simultaneously helping feed post 30 to mechanically separate and hold elongated conductor 32 and shorting arm 34 in position juxtaposed with ground plane 38.

With respect to FIGs. 2 and 9, volume of space 46 residing between elongated conductor 32 and ground plane 38 is filled substantially with air in the preferred embodiments. Air is a desirable dielectric material in the preferred embodiments because its low dielectric constant helps antenna 12 have a high maximum gain. In addition, the lightweight and no cost aspects of air are particularly desirable in a portable telephone application. Of course, nothing prevents varying amounts of other light weight, low dielectric constant materials from being inserted into space 46. For example, dielectric coatings on radiating elements 44 and ground plane 38 are entirely acceptable for the purposes of the present invention.

The above-presented description discusses coupling various ones of radiating elements 44 together and to ground plane 38. However, those skilled in the art will recognize that any two or more of radiating elements 44 may be coupled together by virtue of being integrally formed from a single elongated conductor or wire. Likewise, elongated conductor 32 or other ones of radiating elements 44 may be formed from two or more coupled together elongated conductors or wires.

FIGs. 4-7 and FIG. 9 describe the operation of antenna 12. FIG. 4 shows a perspective view of the first embodiment of antenna 12 with various resonator lengths designated. FIGs. 5 and 6 show impedance curves which characterize first and second resonances of antenna 12. FIG. 7 shows an impedance curve for antenna 12 which characterizes the combined effect of the first and second resonances. FIG. 9 shows a perspective cross-sectional view of an external embodiment of antenna 12. In general, antenna 12 resonates at two distinctly different frequencies. These two resonant frequencies are spaced sufficiently apart so that a subject bandwidth 56 for antenna 12 (i.e., 824 MHz - 896 MHz for an AMPS cellular portable telephone application) resides between the two resonances.

With respect to FIGs. 4, 5, and 9, a lower resonant frequency 58 in antenna 12 results from driving a short in antenna 12. A resonant frequency is characterized by

unusually high resistance and a reactance of around 0 Ω (not shown). Dotted line 60 in FIGs. 4 and 9 illustrates the radiating elements 44 involved in driving the short in antenna 12 for two different embodiments. In particular, these radiating elements extend from feed point 31 through feed post 30 (if present), through only a portion of elongated conductor 32, through shorting arm 34, and through shorting post 36. The frequency of lower resonance 58 is determined by the sum of the lengths of all radiating elements involved in driving the short in antenna 12. The sum of these lengths preferably falls within the range of $\lambda/4 \pm 1\%$ to 20%, and more preferably within the range of $\lambda/4 \pm 5\%$ to 15%, where λ is the wavelength of lower resonance 58.

With respect to FIGs. 4, 6, and 9, a higher resonance 62 results from driving an open in antenna 12. Dotted line 64 in FIGs. 4 and 9 illustrates the radiating elements 44 involved in driving the open in antenna 12. In particular, these radiating elements 44 include feed post 30 (if present) and elongated conductor 32. The frequency of higher resonance 62 is determined by the sum of the lengths of the radiating elements involved in driving the open in antenna 12. The sum of these lengths preferably falls within the range of $\lambda/2 \pm 1\%$ to 20%, and more preferably within the range of $\lambda/2 \pm 5\%$ to 15%, where λ is the wavelength of higher resonance 62.

With respect to FIGs. 4 and 9, a third resonance (not shown) of antenna 12 may be weakly excited by mutual coupling. The third resonance is defined by radiating elements 44 beginning at open end and extending through only a portion of elongated conductor 32 to central region 54, through shorting arm 34 and shorting post 36. These elements cause the third resonance to occur within bandwidth 56 (see FIGs. 5-7).

The radiating element lengths responsible for lower and higher resonances 58 and 62 should not precisely equal $\lambda/4$ and $\lambda/2$, respectively. Such precise lengths are likely to cause standing waves in antenna 12. If antenna 12 were to accommodate standing waves, then the two distinct resonance frequencies would tend to merge into a single resonant frequency. Likewise, the resonance lengths responsible for lower and higher resonances 58 and 62 should not be too far removed from desired resonant frequencies because resulting actual resonant frequencies may cause undesirable impedance effects within bandwidth 56.

A horizontal dotted line 66 in FIGs. 5 and 6 indicates a resistance of 50 Ω, which is a desirable resistance for antenna 12 to exhibit through bandwidth 56. Although not

shown, a reactance of 0 Ω is also desirable. This impedance is desirable because it matches conventional and inexpensive 50 Ω transmission line drive techniques well known to those skilled in the art. Those skilled in the art will appreciate that matching impedances is important to reduce the reflection coefficient between antenna 12 and its feed circuit so that antenna gain may be maintained near its maximum achievable gain. Moreover, this impedance needs to be maintained within reasonable limits throughout relatively wide bandwidth 56. As illustrated in FIGs. 5 and 6, neither lower resonance 58 nor higher resonance 62 considered without the other achieves the desired impedance for antenna 12 through bandwidth 56.

As illustrated in FIG. 7, when the combined effect of lower and upper resonances 58 and 62 is considered, an impedance roughly around 50 Ω is maintained throughout bandwidth 56. Accordingly, antenna 12 is configured so that it has two distinct active resonant frequencies. Lower resonant frequency 58 is positioned below bandwidth 56 and higher resonant frequency 62 is positioned above bandwidth 56. Antenna 12 does not resonate significantly at frequencies within bandwidth 56. However, a weakly excited third resonance of antenna 12 can aid in maintaining impedance at approximately 50 Ω when miniaturization efforts urge radiating elements 44 near ground plane 38. Resonances 58 and 62 may be sharply defined due to the close proximity of ground plane 38 to radiating elements 44. In other words, as frequency changes in the vicinity of a resonance, resistance quickly increases to a peak and quickly decreases. Nevertheless, a relatively wide bandwidth 56 may be accommodated when the decreasing resistance of one resonance combines with the increasing resistance of another resonance to achieve a generally constant resistance of roughly 50 Ω throughout bandwidth 56. Although not shown, in the preferred embodiments, reactance is maintained at around 0 Ω throughout bandwidth 56 as well.

With reference to FIGs. 2, 7, and 9, the combined effects of ground plane 38 and radiating elements 44 produce the gain and bandwidth 56 of antenna 12. If, for example, the distance between ground plane 38 and elongated conductor 32 is reduced, then impedance decreases. This impedance may be compensated for by positioning lower and higher resonances 58 and 62 closer together in frequency. However, positioning lower and higher resonances 58 and 62 closer together tends to narrow bandwidth 56. Alternately, excitation of the third resonance through mutual coupling may provide such compensation.

FIGs. 8, 9, and 10 illustrate an embodiment of the present invention in which dual-resonant antenna 12 is external to portable telephone 10. Telephone 10 includes a housing in which other devices are enclosed. These other devices include speaker 16, display 18, keypad 20, microphone 22, battery 24, and various electronic circuit cards 26, as discussed above in connection with FIG. 1. User direction 28 is also indicated by an arrow in FIG. 8.

Antenna 12 includes feed point 31, elongated conductor 32, a conductive shorting arm 34, a conductive shorting post 36, and a conductive ground plane 38. Elongated conductor 32, shorting arm 34, and shorting post 36 represent radiating elements 44 of antenna 12. Elongated conductor 32 and shorting arm 34 are spaced away from ground plane 38. Elongated conductor 32 has a feed end 30, a central region 54, and an open end 52, with feed end 30 serving as feed point 31. Conductive shorting arm 34 has first and second ends, with the conductive shorting arm first end being coupled to central region 54 of elongated conductor 32 and second end being coupled to ground plane 38. Shorting post 36 is coupled between second end of shorting arm 34 and ground plane 38.

Elongated conductor 32 includes segments arranged to reside in a geometric plane 76 (a hypothetical geometric figure, which need not be physically part of any embodiment of present invention). Geometric plane 76 extends generally in user direction 28.

Elongated conductor 32 comprises a first segment 66 extending from feed point 31 to central region 54; a second segment 68 extending from central region 54 in a direction substantially opposing user direction 28; and a third segment 70 extending from second segment 68 in a direction substantially parallel to first segment 66. Third segment 70 extends from second segment 68 generally toward feed point 31.

First segment 66 is substantially collinear with shorting arm 34, allowing for a longer conductor 32 relative to the overall length for antenna 12. In other words, antenna 12 can be shorter in height by having first segment 66 and shorting arm 34 substantially collinear.

Pointing third segment 70 substantially toward feed point 31 (rather than upward toward top of antenna 12) allows antenna 12 to be shorter in height, and allows better mutual coupling. The mutual coupling weakly excites the third resonance discussed

above. This compensates for any reduction in impedance that results from miniaturizing antenna 12.

The arrangement of elongated conductor 32 in geometric plane 76 allows ground plane 38 to be fairly compact. If third segment 70 were outside geometric plane 76, either antenna 12 would have to be larger in diameter in order to accommodate elongated conductor 32, or impedance would drop, resulting in unsatisfactory performance.

Ground plane 38 resides closer to first segment 66 than third segment 70. The positioning of ground plane 38 substantially between user's head and antenna 12 allows ground plane 38 to shield the near field in user direction 28, where user's head resides during normal use of telephone 10.

With reference to FIGs. 9 and 10, antenna 12 either resides within or is juxtaposed with a non-conductive housing 72 which is elongated in a direction defined by a housing axis 74. First segment 66 extends substantially along housing axis 74. Third segment 70 extends substantially parallel to but spaced apart from housing axis 74. Placing feed point 31 (on housing axis 74) in the center of antenna 12 facilitates installation of antenna 12 on connectors having a centrally located feed point.

While FIGs. 9 and 10 depict an embodiment of the present invention in which ground plane 38 is juxtaposed with the inner surface of antenna housing 72, this is not a requirement of the present invention. This depiction makes it convenient to metalize such an inner surface of antenna housing 72, and allows the weight of ground plane 38 to be supported by antenna housing 72. Nothing prevents ground plane 38 from being juxtaposed with the outer surface of antenna housing 72, nor from being enclosed within layers of antenna housing 72. Also, while FIGs. 9 and 10 depict an embodiment of the present invention in which ground plane 38 forms roughly half of a cylinder, nothing prevents ground plane 38 from being squared, elliptical, or some other shape.

In summary, the present invention provides an improved dual resonance antenna 12 and associated portable telephone 10. Antenna 12 is lightweight, small and inexpensive because it uses small, lightweight and simple radiating elements 44 which may be arranged in a spiral or in an external configuration and need not be supported by substrates. In addition, antenna 12 uses an air dielectric between radiating elements 44 and ground plane 38. The ground plane 38 can be formed on the back of an existing circuit card or juxtaposed with antenna housing 72. Antenna 12 and portable telephone

10 emit a transmitted signal pattern that is substantially omnidirectional in the far field but directional away from a portable telephone user in the near field. Antenna 12 has a relatively wide bandwidth since antenna resonances are placed to maintain roughly constant impedance throughout the bandwidth. This impedance is desirable around 50 Ω throughout the subject bandwidth to enable driving by simple, inexpensive drive circuitry.

The present invention has been described above with reference to preferred embodiments. However, those skilled in the art will recognize that changes and modifications may be made in these preferred embodiments without departing from the scope of the present invention. For example, those skilled in the art will appreciate that alternate arrangements of radiating elements 44 can be devised while achieving equivalent results. Moreover, the teaching of the present invention may be applied to antennas which are used in connection with radio equipment other than portable telephones. These and other changes and modifications which are obvious to those skilled in the art are intended to be included within the scope of the present invention.

CLAIMS

What is claimed is:

1. A dual resonance, wide bandwidth antenna (12) having an antenna bandwidth (56) positioned between resonances and attenuated near field response in one direction (28) comprising:

a conductive ground plane (38);

a conductive feed point (31);

an elongated conductor (32) spaced away from said ground plane (38), said elongated conductor (32) having a feed end (50) and an open end (52), said feed end (50) being coupled to said conductive feed point (31);

a conductive shorting arm (34) having first and second ends, said conductive shorting arm (34) first end being coupled to said elongated conductor (32) in a central region (54) of said elongated conductor (32), and said conductive shorting arm (34) being spaced away from said ground plane (38); and

a shorting post (36) coupled between said second end of said shorting arm (34) and said ground plane (38).

2. An antenna (12) as claimed in claim 1 wherein:

said bandwidth (56) is positioned between a lower resonant frequency (58) and a higher resonant frequency (62), said lower resonant frequency (58) being characterized by a wavelength λ; and

the sum of lengths from said feed point (31), through said elongated conductor (32) from said feed end (50) to said shorting arm (34), through said shorting arm (34) between said first and second ends thereof, and through said shorting post (36) is approximately equal to $\lambda/4 \pm 20\%$.

3. An antenna (12) as claimed in claim 2 wherein:

said higher resonant frequency (62) is characterized by a wavelength λ_h; and

the sum of lengths from said feed point (31) through said entire elongated conductor (32) is approximately equal to $\lambda_h/2 \pm 20\%$.

4. An antenna (12) as claimed in claim 3 wherein said bandwidth (56) includes the frequency range 824 - 896 MHz and said antenna (12) is configured so that said lower resonant frequency (58) is less than 824 MHz and said higher resonant frequency (62) is greater than 896 MHz.

5. An antenna (12) as claimed in claim 2 wherein said sum of lengths is outside the range defined by $\lambda/4 \pm 1\%$.

6. An antenna (12) as claimed in claim 1 wherein:

said bandwidth (56) is positioned between a lower resonant frequency (58) and a higher resonant frequency (62), said higher resonant frequency (62) being characterized by a wavelength λ; and

the sum of lengths from said feed point (31) through said entire elongated conductor (32) is approximately equal to $\lambda/2 \pm 20\%$.

7. An antenna (12) as claimed in claim 6 wherein said sum of lengths is outside the range defined by $\lambda/2 \pm 1\%$.

8. An antenna (12) as claimed in claim 1 wherein said ground plane (38) is spaced apart from said elongated conductor (32) in cooperation with the length of said shorting post (36), the length of said shorting arm (34) and a precise position in said central region (54) of said elongated conductor (32) at which said shorting arm (34) couples to said elongated conductor (32) to cause said antenna (12) to exhibit an impedance of around 50 Ω throughout said bandwidth (56).

9. An antenna (12) as claimed in claim 1 wherein said elongated conductor (32) is arranged in a spiral.

10. An antenna (12) as claimed in claim 1 wherein said elongated conductor (32) is constructed from a material which supports its own weight without deforming.

11. An antenna (12) as claimed in claim 1 wherein:

a volume of space (46) resides between said elongated conductor (32) and said ground plane (38); and

said volume of space (46) is substantially filled with air.

12. An antenna (12) as claimed in claim 1 wherein said portion of said elongated conductor (32) extending between said feed end (30) and said shorting arm (34) is substantially collinear with said shorting arm (34).

13. A dual resonance, wide bandwidth antenna (12) having an antenna bandwidth (56) positioned between resonances and attenuated near field response in one direction (28) comprising:

a conductive ground plane (38);

a conductive feed point (31);

an elongated conductor (32) spaced away from said ground plane (38), said elongated conductor (32) having a feed end (50), a central region (54), and an open end (52), said feed end (50) being coupled to said conductive feed point (31);

a conductive shorting arm (34) having first and second ends, said conductive shorting arm (34) first end being coupled to said central region (54) of said elongated conductor (32), and said conductive shorting arm (34) being spaced away from said ground plane (38), wherein a portion of said elongated conductor (32) extending between said feed end (50) and said shorting arm (34) is substantially collinear with said shorting arm (34); and

a shorting post (36) coupled between said second end of said shorting arm (34) and said ground plane (38).

14. An antenna (12) as claimed in claim 13 wherein:

said elongated conductor (32) includes segments (66,68,70) arranged to reside substantially in a geometric plane (76); and

said geometric plane (76) extends generally in said one direction (28).

15. An antenna (12) as claimed in claim 13 wherein said elongated conductor (32) comprises:

a first segment (66) extending from said feed point (31) to said central region (54);

a second segment (68) extending from said central region (54) in a direction substantially opposing said one direction (28); and

a third segment (70) extending from said second segment (68) in a direction substantially parallel to said first segment (66).

16. An antenna (12) as claimed in claim 15 wherein said third segment (70) extends from said second segment (68) generally toward said feed point (31).

17. An antenna (12) as claimed in claim 15 wherein said ground plane (38) resides closer to said first segment (66) than said third segment (70).

18. An antenna (12) as claimed in claim 15 wherein:

said antenna (12) resides within a non-conductive housing (72) which is elongated in a direction defined by a housing axis (74); and

said first segment (66) extends substantially along said housing axis (74).

19. An antenna (12) as claimed in claim 18 wherein said ground plane (38) is juxtaposed with said non-conductive housing (72).

20. A portable telephone (10) for which an electrical field for transmitted energy is attenuated in the vicinity of a user's head, said portable cellular telephone (10) comprising:

a portable telephone housing (14) for which a first direction (28) points toward a user's ear when said portable telephone (10) is in use;

a conductive ground plane (38);

a conductive feed post (30);

an elongated conductor (32) spaced away from said ground plane (38) in a direction substantially opposite to said first direction (28), said elongated conductor (32) having a feed end (50) coupled to said conductive feed post (30);

a conductive shorting arm (34) having first and second ends, said conductive shorting arm (34) first end being coupled to said elongated conductor (32) in a central region (54) of said elongated conductor (32), and said conductive shorting arm (34) being spaced away from said ground plane (38); and

a shorting post (36) coupled between said second end of said shorting arm (34) and said ground plane (38).

21. A portable telephone (10) as claimed in claim 20 additionally comprising a circuit card (26) having electronic components (42) mounted on a substrate (40), said circuit card (26) being oriented substantially parallel to said ground plane (38) and so that said substrate (40) is positioned toward said first direction (28) from said ground plane (38).

22. A portable telephone (10) as claimed in claim 21 wherein said ground plane (38) is clad onto said substrate (40).

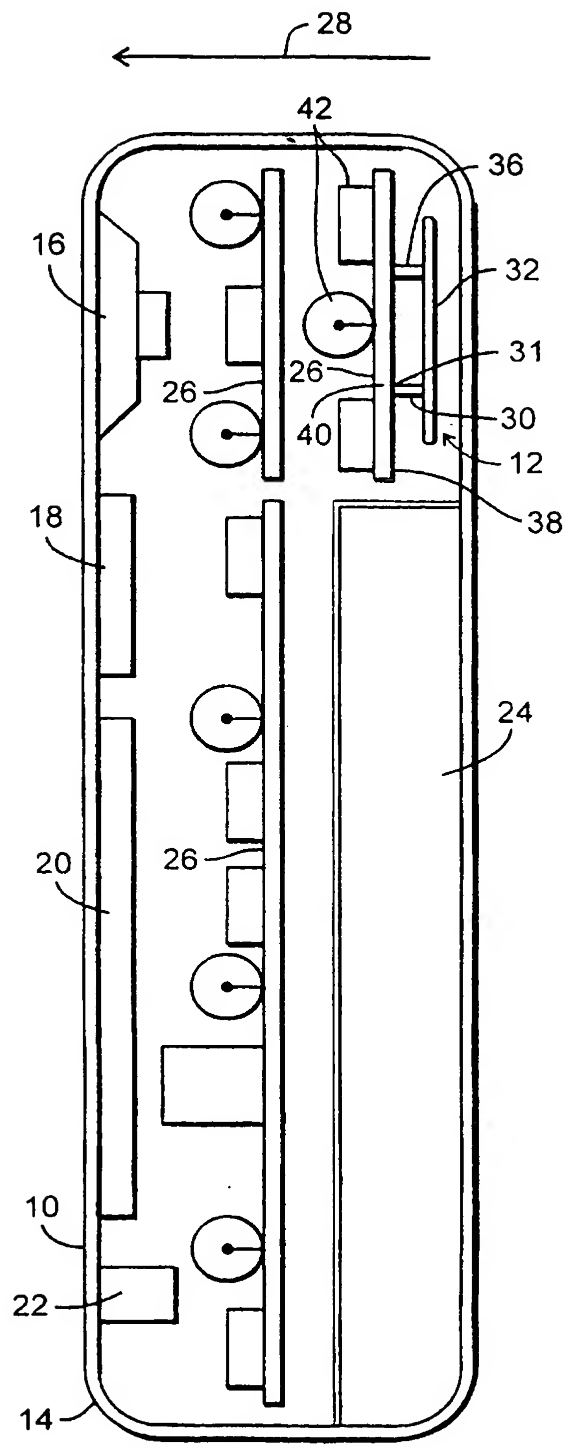


Fig. 1

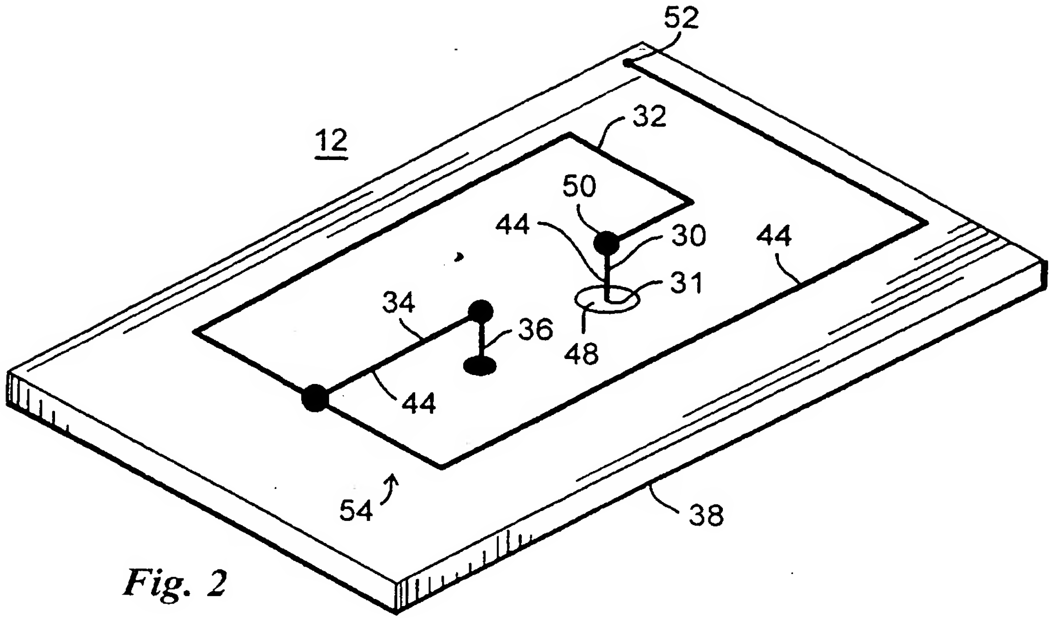


Fig. 2

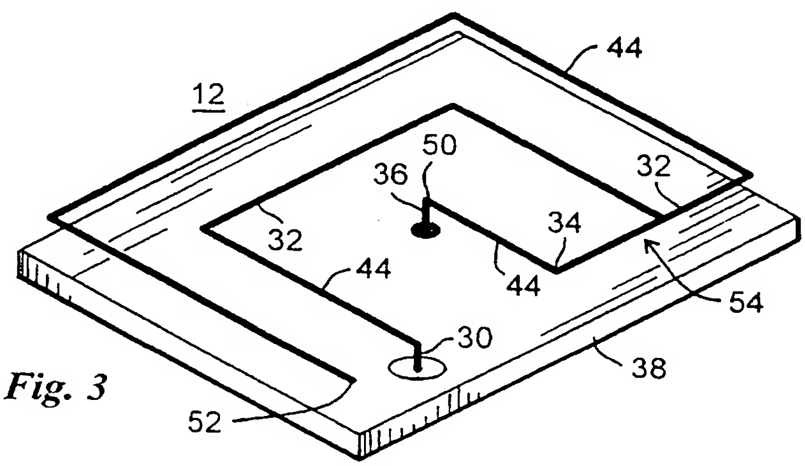
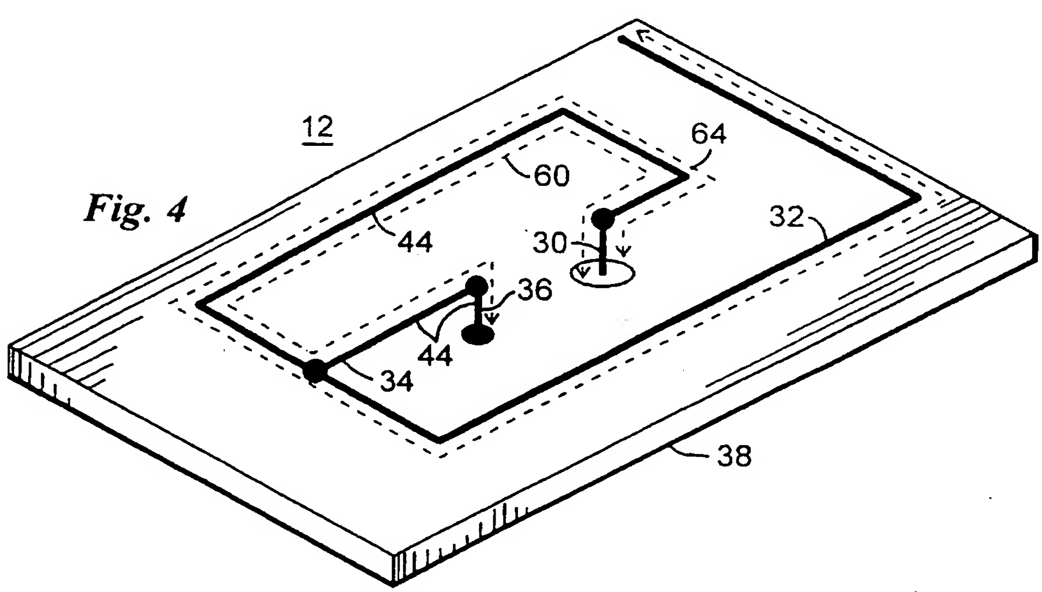


Fig. 3

Fig. 4



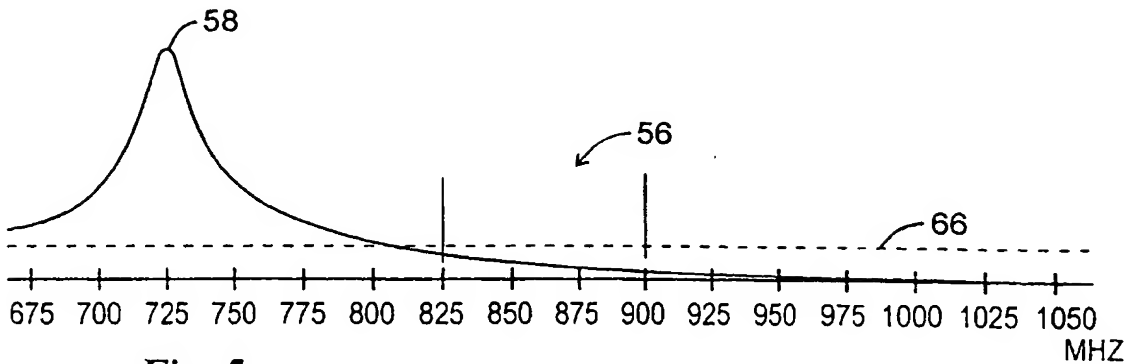


Fig. 5

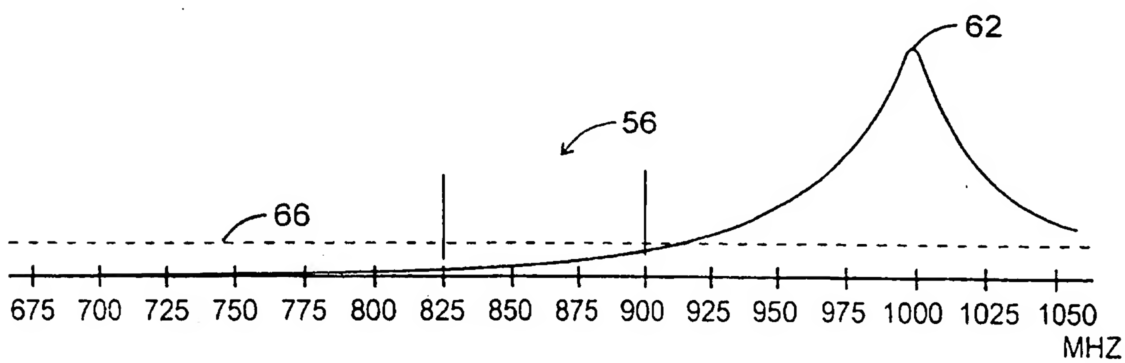


Fig. 6

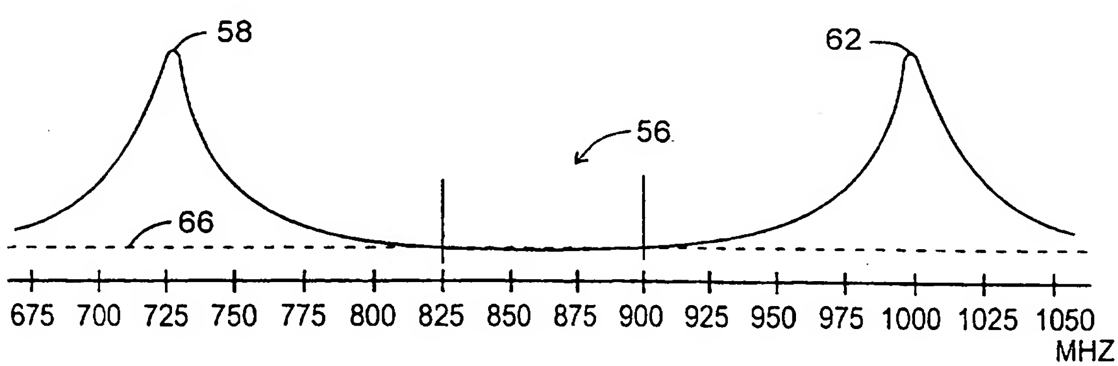


Fig. 7

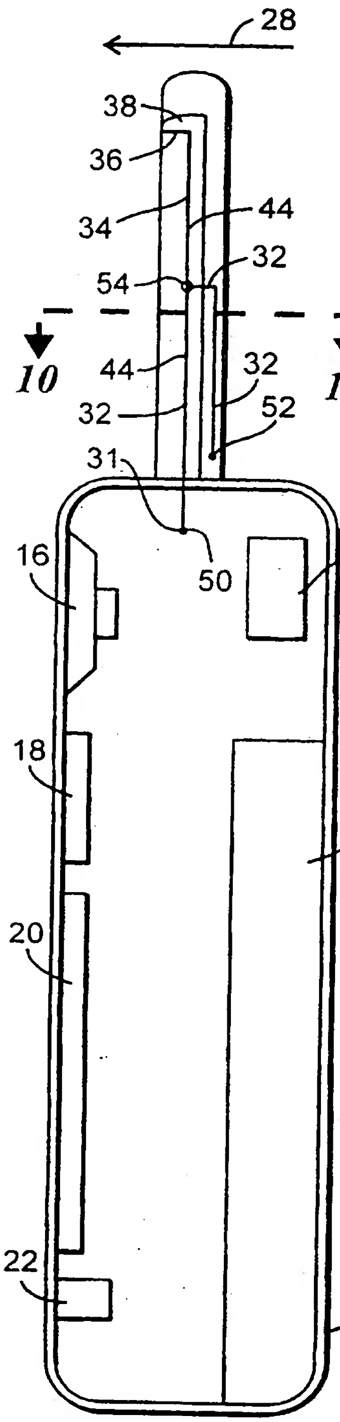


Fig. 8

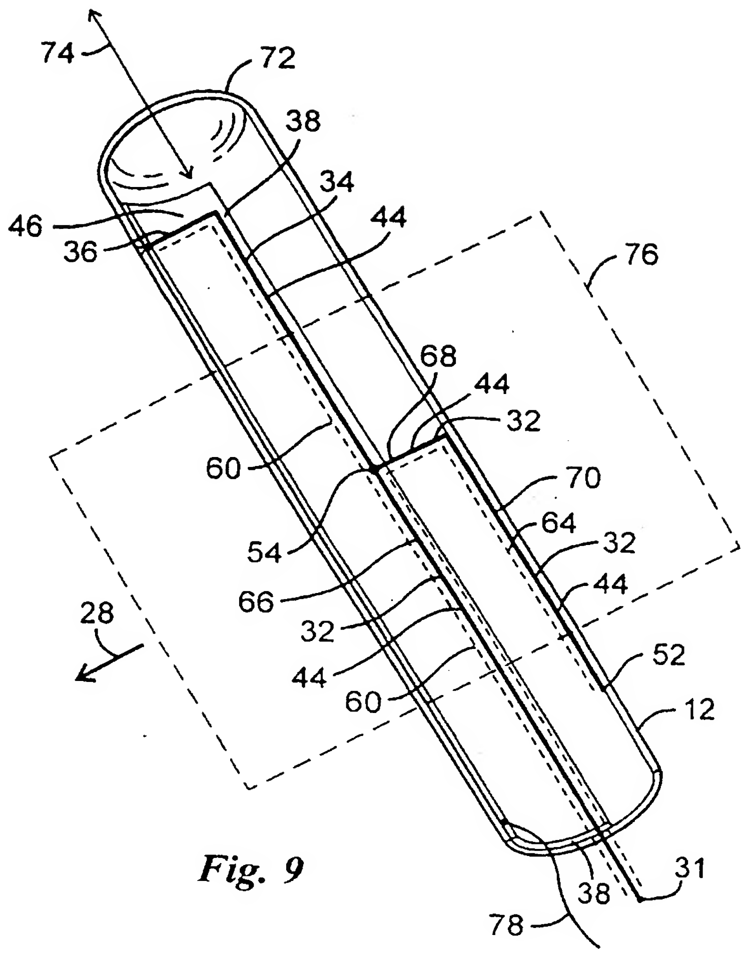


Fig. 9

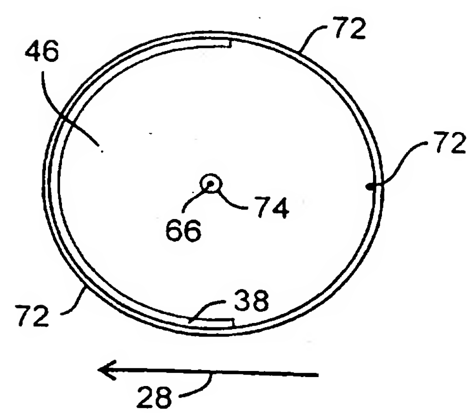


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/07227

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :H01Q 1/24
US CL :343/702, 741
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 343/700 MS, 702, 741, 742, 846, 848

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 4,924,237 A (HONDA ET AL) 08 MAY 1990 (08/05/90), Figures 1 and 10.	1,8,10-22 ------------- 9
Y	US 3,568,206 A (SISSON ET AL) 02 March 1971 (02/03/71), Figures 1-3.	9

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

28 JULY 1997

Date of mailing of the international search report

14 AUG 1997

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
Michael C. Wimer
Telephone No. (703) 305-3555

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